CORRESPONDENCE

Discussion of "A Modulated Soil Moisture Budget"

M. A. KOHLER

U.S. Weather Bureau, Washington, D.C.

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Holmes and Robertson [1] have demonstrated that mean monthly moisture deficiency is better correlated with wheat yield when it is derived by application of a budget which considers moisture stress and variable root zone than when it is derived from one which neglects these factors. They state that "one might wonder why the correlations with yield of wheat are not higher" and cite Hopkins' view that "inhibitory factors such as wind, disease, weeds, insects, etc., are important in many seasons." The writer feels, however, that one might question the reality of the high correlation found (0.68) in view of the assumed linear effect of mean monthly deficiency. Certainly the yield would approach zero if the deficiency for a brief period of days were sufficiently severe even though the monthly and season values were not critical.

What the authors choose to call a modulated budget is similar in important respects to that employed by the Weather Bureau in connection with its river forecasting program [2, 3]. The differences in the two methods are largely necessitated by virtue of the fact that we maintain the budget for a basin (the order of 100 to 500 sq. mi.), while the authors are concerned with a particular plot or field. Thus while we use a two-layer system, we have not found it necessary to vary the two moisture capacities for changes in root zone.

For the basin, we have and use total runoff (surface and percolation) as an item in the budget, whereas the authors must assume that runoff occurs only when the soil profile is saturated. It should be pointed out that observations of rainfall and runoff show that the concept of a saturation threshold is not sound and results in large errors of estimated daily runoff. Using this concept, one is forced to select unrealistic values of soil moisture capacity if the accounting is to provide the correct evapotranspiration over extended periods.

The authors contend that evaporation pans are "cumbersome and are not free of structural disadvantages" and have purported to show in an earlier publication [4] that the Bellani plate atmometer provides better results than can be obtained from a pan. Their comparative studies have been restricted to a 4-foot sunken pan of the type used in Canada and the conclusions do not necessarily apply to the Class A pan used in the United States which is free of heat exchange with the soil. All known evaporation instruments possess decided deficiencies and the Bellani plate atmometer is no exception. It can be used only during those months when the minimum temperatures are above freezing and it requires repeated calibration to avoid time trends in the data.

We have found [5] that free-water evaporation can be estimated from that of a Class A pan or from certain meteorological factors with about equal reliability. In either case, our moisture budget computations are based on the assumption that free-water evaporation and potential evapotranspiration are equivalent. The computation of potential evapotranspiration from solar radiation, air and dewpoint temperatures, and wind, as well as the moisture budget computations, can be performed on an IBM 650 computer [6].

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Reply

R. M. HOLMES AND G. W. ROBERTSON

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It has been our experience that while periods of a few days of high moisture stress certainly influence the yield of spring wheat, the effect is not marked unless the deficiency occurs at the time of germination and emergence. According to our budget, the Lethbridge plots were never depleted of available moisture during the entire 36-year period, although the supply was low oftentimes. Any drought periods that affected yield were of sufficient length to be accurately accounted for on a monthly basis. In other words, rainless periods of a week or less were overcome because of moisture held in the low root zones. However, if the drought persisted for longer periods, even this store of moisture became depleted and the effect on the yield was marked.

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mean troughs, on the western fringe of the precipitation areas, there were periods of both ascending and descending motion associated with the lifting and precipitation north and east of the daily storms and the subsidence in the cool air behind these same storms as they moved eastward. The availability of moisture, which is an additional requirement for precipitation, has not been considered in this brief investigation, and should be included in any further study.

6. ALASKAN COLD AND HAWAIIAN WARMTH

Most of Alaska experienced a record-breaking cold March (table 1). Barrow, Fairbanks, and Nome, well distributed stations with long periods of record, had the coldest March on record and Anchorage the second coldest. Departures from normal of the monthly mean temperatures were as large as two or three standard deviations, a rather rare event. Fairbanks, with 16° F. below normal, had the most extreme anomaly, but Barrow, with a frigid mean temperature of 27° F. below zero, suffered the coldest weather in the absolute sense. At the latter city the maximum daily temperature did not exceed −5° F., and the minimum was always colder than −21° F.

This cold over Alaska was produced by stronger than normal flow between the mean ridge over eastern Siberia and the trough over Alaska (fig. 1), which continually advected cold air masses from the Arctic Basin into Alaska. This was a very persistent pattern, as illustrated by the 5-day mean trough and ridge frequencies (fig. 4) and produced over Alaska the coldest mean thickness anomaly for the Northern Hemisphere (fig. 5).

While the Alaskans were shivering in record-breaking cold weather, the Hawaiians basked in record-smashing warmth (table 1). At Honolulu, the daily maxima averaged 79° F. and the minima 71° F. for the month of March. Of more significance was the monthly mean temperature of 74.7° F., the absolute highest since records began in 1905. This month's mean temperature represents a departure of +2.5° F., which is large for this subtropical station that has a standard deviation of only 1.0° F. Similar weather was experienced at Lihue, Kauai, where a record monthly mean temperature of 74.3° F. produced an anomaly of +3.7° F., almost 3 standard deviations above normal.

This warmth was associated with a deficit of precipitation at both stations. Honolulu reported only 0.17 inch, 2.13 inches below normal, and Lihue had 1.37 inches, 2.70 inches less than normal.

Table 1.—*Alaskan and Hawaiian surface temperatures (° F.) for March 1959*

Station	Monthly mean	Normal	Anomaly	Standard deviation	Year records start
Alaska					
Anchorage	14.0	24.8	−10.8	4.6	1916
Barrow	*−26.6	−14.9	−11.7	4.0	1921
Fairbanks	*−6.6	9.0	−15.6	6.0	1906
Juneau	33.8	32.8	+1.0	2.8	1915
Nome	*−5.3	8.5	−13.8	6.8	1907
Hawaiian Islands					
Honolulu	*74.7	72.2	+2.5	1.0	1905
Lihue	*74.3	70.6	+3.7	1.3	1905

*Record for March.

The dry and extremely warm weather occurred with a stronger than normal subtropical ridge in the eastern and central Pacific. Over the Hawaiian Islands 700-mb. mean heights (fig. 1), 1,000–700-mb. mean thicknesses, and sea level mean pressures were all above normal during March.

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We were not aware of a similar modulated technique in use by the Weather Bureau.

We are aware that saturation thresholds are somewhat difficult to work with, but for conditions of level plot land, we assume that a saturation point exists and that any precipitation in excess of this value is runoff and hence lost as far as crop use is concerned.

During the past year we have had the opportunity to compare atmometers with the Class A pan, and the buried 4-foot pan. These observations have not caused us to alter our point of view on the disadvantage of pans, generally. Frost is a serious limitation to the use of atmometers. (In this connection we have been experimenting with an instrument which withstands 7 degrees of frost.) Our co-workers in Canada have noticed time trends in Bellani plate atmometers only when air enters the cup or when the surface color or porosity changes because of dirt or accumulated salts.

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